Economic Development Through Biomass Systems Integration in Central Florida

Final Report

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Summary

Reclaimed phosphate mined land in central Florida has been identified as an area with potential for growing biomass crops. Approximately 73,000 acres of land could be available for biomass production should fuel from biomass systems prove profitable. Environmental impacts from large scale dedicated feedstock supply systems (DFSS) should be minimal provided best management practices are followed. A major environmental benefit for biomass/energy production is the reduction of buildup of carbon dioxide in the atmosphere by recycling carbon dioxide. Utilization of waste streams from ethanol production may be further exploited for production of methane gas or for direct combustion. Another possibility is production of animal feed. Additional research is needed to fully define the possibilities.

A total of six crops have been identified as having the most potential for biomass production. They include the tall tropical grasses; sugarcane, energycane, and elephantgrass (also called napiergrass); leucaena (a woody tropical legume); Eucalyptus, and slash pine. Yields of the different crops vary according to the soil type and range from a high of 22 dry tons per acre, for sugarcane on phosphatic clay soil, to a low of 9 tons per acre for two varieties of Eucalyptus and slash pine. The crop with the lowest estimated production cost per dry ton was leucaena on phosphatic clay at $3.45 per dry ton. The largest single cost component for biomass production was harvest costs. The most cost effective harvest method appeared to be a high capacity forage chopper.

A regional biomass supply curve was developed with annual production levels ranging from 100,000 to 1,000,000 dry tons. A mixture of 7 crops including 3 varieties of Eucalyptus was assumed. Crops were selected to give a year-round supply of feedstocks to minimize the need for long term storage. Production costs ranged from around $25.00 per dry ton for 100,000 tons to about $27.25 per ton for 1,000,000 tons. Production and conversion of 500,000 dry tons of biomass each year is expected to generate $66,340,000 in total output of goods and services in the local economy plus 606 jobs.

Average transport distances for moving biomass materials from the field to the processing plants are projected to be relatively short. Average distances average about 10 miles. Projected travel time in relation to loading and unloading times was such that hourly rates rather than mileage rates were used to estimate transportation costs. Moisture content of biomass material was the most important factor in determining transportation costs. Field drying of some crops greatly reduced the transportation costs.

Sugarcane appears to be the most versatile biomass crop. Sugarcane may be harvested, pressed to remove approximately 85% of the sugars in the juice. The juice may be fermented into ethanol with conventional technology. The presscake can be hydrolyzed and the hemicellulose converted to ethanol. Cellulose might also be converted to ethanol or the cellulose and lignin might be used in an anaerobic process to make methane. The material might also be burned directly as boiler fuel. The moisture content of presscake, after pressing, is in the range of 60 to 70% which is too wet for efficient combustion. Wet presscake produced only about 2,500 BTU/lb when burned while dried presscake produced almost 6400 BTU/lb. Efficient methods are needed to dry the presscake or the remaining cellulose and/or lignin.

Potential ethanol yield per dry ton of sugarcane is 57 gal for juice, 30 gal from remaining sugars and hemicellulose and 32 gal from cellulose for a total of 119 gal. Presently cost for cellulose conversion is too high to be economically feasible. Research is expected to bring

the cost down. With a sugarcane yield of 22 dry tons per acre each acre of sugarcane could produce a total of 2,618 gal of ethanol. The remaining lignin would still be available for direct combustion. With multiple uses of one feedstock the feedstock cost for additional processes is dramatically reduced.

In addition to their use as feedstocks for lignocellulose conversion to ethanol, sugarcane, presscake, elephantgrass, leucaena, and Eucalyptus may prove to be superior feedstocks for valuable products such as high purity cellulose and other chemicals. NREL's Clean fractionation process of separation of materials into constituents of cellulose, hemicellulose, and lignin shows great promise in offering an efficient and economical method opening the way of all three biomass fractions as sources of valuable chemicals and materials. This process could potentially offer glucose and xylose at lower cost for conversion to ethanol or for other marketable products, as well as making the lignin available for profitable uses. Patent applications for this process have been filed and further information is scheduled to be presented in the next few months. Biomass crops such as those grown on reclaimed phosphate are being considered as feedstocks for this process.

Based on project findings, a three phase scale up of a biomass to energy system is proposed. The first phase would be a cooperative effort with an existing conventional ethanol plant in the community. Enough sugarcane (about 250 acres) would be planted to supply the plant with feedstock for about 30 days. Equipment to hydrolyze the hemicellulose in the presscake would be added to the plant. The hemicellulose derived sugars would be fermented with genetically altered bacteria to produce ethanol. Data generated through this process would be used to develop a demonstration plant.

The second phase would include a demonstration plant with an ethanol capacity of 5,000,000 gal per year. It would be a hybrid plant combining conventional dry milling corn to ethanol with two biomass feedstocks; sugarcane and elephantgrass. The plant would operate with sugarcane, sugars and presscake, during the sugarcane harvest season (about 100 days). For the rest of the year (about 230 days) the plant would operate on elephantgrass and corn. The hyrolyzer would be sized to handle all of the presscake as it is being made; which would be about 177 dry tons of sugarcane per day. About 800 to 1,000 acres of sugarcane would be needed. The elephantgrass would be processed at about 89 dry tons per day, a rate that is equivalent to the daily processing of presscake. About 1,000 to 1,200 acres of elephantgrass would be needed.

Output from the plant would be 1.5 million gallons of ethanol per year from sugarcane, 750,000 gallons from elephantgrass, and 2.75 million gal from corn. The estimated net feedstock cost would be $0.14 for sugarcane, $0.40 for elephantgrass, and $0.50 for corn. Total revenue for the plant is estimated to be $8 million if CO^2 is sold for $25 per ton, remaining cellulose/lignin for $10 per dry ton, Distillers dried grains (DDGs) for $125 per ton, and ethanol sells for $1.25 per gal. Total revenue per gal of ethanol is estimated to be $1.61 per gal and cost are estimated to be $1.39 per gal.

The third phase would be a commercial plant with a total capacity in excess of 23,000,000 gal per year. The commercial plant would be built around a 5,000,000 gal per year conventional ethanol plant, coupled with a lignocellulose conversion facility. Approximately 4,500 acres of sugarcane would supply the conventional facility with about 30% of the juice going directly to the plant during the harvest season and 70% concentrated to 70 degrees Brix and stored to operate the plant for the remaining part of the year.

The lignocellulose facility will be sized to convert all of the sugarcane presscake produced during the approximately 100 day harvest season and be available to convert elephantgrass, leucaena, Eucalyptus or other biomass materials for the rest of the year. Presscake is expected to produce 6,200,000 gal of ethanol and other biomass, 12,400,000 gal. A mix of crops, to spread harvest over most of the year, will be used to better utilize equipment and reduce the need for long term storage of biomass materials. In addition to sugarcane about 10,000 acres of crop would need to be harvested each year to supply the plant, assuming a 68% conversion efficiency.

Objectives

* Identify land for growing biomass crops and relate land location to location of present and potential conversion facilities.

* Identify potential biomass crops and estimate production and harvest costs for each crop and soil type.

* Evaluate environmental impact of large scale biomass production in central Florida and develop best management practices for biomass crops.

* Evaluate economic and social impact of biomass/energy systems in central Florida.

* Expand the supply of planting material for selected biomass crops.

* Evaluate biomass materials handling, storage and processing costs.

* Determine conversion rates for converting selected biomass materials to energy in various forms.

* Conceptually combine individual biomass/energy components into an economical, workable system.

* Identify land and conversion plant requirements for biomass to energy systems from a pilot scale to commercial production.

* Identify additional research needs for commercialization of biomass to energy systems.